CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-161

Northern Segment of the

White Mountains Fault Zone

and the

Benton Valley and Black Mountain Faults

Mono County, California

by

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April 5, 1984

INTRODUCTION

The study area lies immediately southeast of the Mono Basin within a large triangular-shaped graben bounded on the west by the Sierra Nevada and on the east by the White Mountains. Within this graben lie volcanic rocks, extruded during late Tertiary and Pleistocene time, which have been faulted forming several smaller basins and ranges (i.e., Adobe Valley, Blind Spring Hill, and the Benton Range; Gilbert, 1941; Pakiser and others, 1964).

The White Mountains fault zone is the major fault zone which forms the eastern boundary of this triangular-shaped graben. Bryant (1984) has concluded that segments of this fault zone located south of the area evaluated herein are sufficiently active (Holocene) and well defined. The Benton Valley fault (named herein) may be a relatively minor, northwest-trending branch of the White Mountain fault zone. Several investigators indicate that the Benton Valley fault has offset young alluvial deposits and, therefore, that the fault has been active during Holocene time (Anderson, 1933; Gilbert, 1938; 1941; Crowder and others, 1972). The Black Mountain fault (named herein) is another relatively minor, north-trending zone of faults located in the southern part of Adobe Valley and on Black Mountain. Krauskopf and Bateman (1977) indicate that some of the faults in the Black Mountain fault zone offset Pleistocene alluvial fan deposits.

The White Mountains fault zone, Benton Valley fault, and Black Mountain fault are being evaluated as part of a state-wide effort to evaluate faults for recency of movement. Those faults determined to be sufficiently active and well-defined are recommended for zoning by the State Geologist as directed by the Alquist-Priolo Special Studies Zones Act of 1972 (see Hart, 1980).

The faults evaluated in this FER lie in the Glass Mountain and the west 1/2 of the Benton 15-minute quadrangles (see Figure 1).

SUMMARY OF AVAILABLE DATA

One of the earliest maps of the study area was that of Anderson (1933). He concluded that both Benton Valley and Queen Valley (Figure 2A) were grabens bounded by steeply dipping, normal faults. He based this conclusion largely on the existence of steep escarpments bordering the valleys.

Anderson described the northwest-facing scarp across the Queen Canyon fan in Nevada (Figure 2A). According to Anderson, the height of this scarp ranges from 10 to 15 feet (3 to 5 m) high to 75 to 100 feet (25 to 30 m) high (though he does not specify that the highest part of the scarp is in alluvium). He concluded that this scarp across the fan was clear evidence of activity along the "Montgomery fault zone" (as he called the White Mountains fault zone) during Quaternary time. He also states, in a footnote, that several recent fault scarps in alluvium are present along the "Montgomery scarp" south of the area he studied (and also south of the area evaluated herein). That these scarps exist in young deposits has been confirmed by Crowder and Sheridan (1972) and Bryant (1984). Anderson estimated that the total displacement along the "Montgomery fault zone" amounts to about 8000 feet (2400 m).

Anderson (1933, p. 149) inferred that a northwest-trending branch of the "Montgomery fault" extends beneath the recent alluvial fans to Pellesier Ranch (labeled Bramlette Ranch on the current base map, now known as Benton Valley Ranch). He does not describe his reasons for reaching this conclusion, but it is likely that he saw the scarp and line of springs northwest of the ranch which have been documented by later workers.

Although Anderson's map shows a single (normal) fault bordering the northern end of Benton Valley and Queen Valley, his text indicates that the zone southwest of Nichols (located about 2 miles NE of Queen, Nevada) is really a zone of distributive, short, mostly west-trending faults in the basalt. He estimated that the cumulative displacement across this zone is about 1000 to 1200 feet (300 to 400 m).

Anderson also concluded that a normal fault exists along the northeast flank of Blind Spring Hill (Figure 2B). He called this fault the "Comanche fault", but did not describe it in any detail.

Gilbert (1938) reported that a rectilinear pattern of faults exists in the area. However, he noted he could find few exposures of faults in the region. He reported that an exception was a north-south trending fault exposed in a canyon about 1 mile west of Benton (possibly an extension of the faults mapped by Anderson, 1933, and Crowder and others, 1972). Here the fault dipped 70° (presumedly to the east). Elsewhere, Gilbert deduced that the dips of the normal faults in the area were about 60° to 75°.

Gilbert's text contains a number of generalities concerning the uplift apparent in the area. He indicates that the White Mountains have been uplifted 7000 to 8000 feet (2100 to 2400 m); the Glass Mountain range has been uplifted 3500 to 4000 feet (1000 to 1200 m); and, the Benton Range has been uplifted 500 to 1000 feet (150 to 300 m), as has Blind Spring Hill. He neither named nor described in any detail the faults along which this uplift has occurred. The primary evidence he cites for the existence of the faults he mapped is geomorphic -- the presence of a steep escarpment along the range fronts and the "youthful" drainages adjacent to the escarpments.

In addition to these general statements, Gilbert (1938, p. 166), cites a line of a "half a dozen" springs or seeps in alluvium northwest of Pelesier Ranch (Bramlette Ranch on Figure 2A) which he felt could only be explained by the presence of a fault. However, in a later paper, Gilbert (1941, p. 805) appeared to soften his conviction, stating:

> "Lastly, lines of seeps and springs commonly indicate the location of a fault. The most notable example... is... near Pellesier Ranch. Only alluvium is exposed there but the logical explanation of a half a dozen springs in line is the existence of a fault."

Crowder and others (1972) inferred that the White Mountains are bordered by a steeply dipping, northwest-trending fault which has been active during Holocene time. They base their conclusion on the steep west-facing escarpment which borders the range and from "scarplets" that traverse the upper parts of older alluvial fans in the White Mountain Peak 15-minute quadrangle to the south. They do not depict any fault cutting or concealed by young alluvium along this zone, although they clearly show such a fault cutting young alluvium in a cross-section. Of the Benton Valley fault (which they do not name), they state "The linear escarpment in Quaternary alluvium... probably represents Holocene movement along this [the White Mountains] major fault or fault zone." Thus, it is clear from their discussion that they believe that this range-front zone of faults connects with the Benton Valley fault and not with the scarps on the southwest side of Queen Valley (Nevada).

Crowder and others (1972) do not describe the northwest-trending faults they depict cutting young alluvial deposits southwest of Benton (Figure 2B). However, they indicate that the eastern block has dropped relative to the western block along these faults.

Krauskopf and Bateman (1977) identified numerous linear and curvilinear normal faults. They depict many of the faults as bordering valleys filled with Holocene and Pleistocene valley fill but specify in their legend that, although they depict such faults with as solid line, these faults are actually concealed by alluvium and slopewash. Some of the faults they mapped are shown as cutting Pleistocene fan deposits. Only in one location (Section 24, T. 1 S., R. 30 E., Figure 3, sheet C) is a fault depicted as clearly cutting Holocene and Pleistocene alluvial deposits. However, elsewhere along this same fault this same unit is shown as concealing the fault.

Krauskopf and Bateman (1977) state:

"Active faulting has continued to geologically recent time, as shown by small scarps in older alluvial fans, and historic earthquakes in the general region indicate that the deformation may still be in progress.... The actual pattern of faulting may well be more complex than is shown on the map, very likely consisting of intersecting or en echelon segments rather than continuous curved lines."

Also, they state that the faults in the basalt-covered areas have displacements ranging to about 100 m (330 feet). Based on their estimate and since the age of the basalt is 3 to 4 million years, the rate of displacement on each of these faults would range up to about 0.025 to0.033 mm/yr.

Krauskopf and Bateman indicate that recent displacement may have occurred along the Black Mountain fault (which they do not name). They base their opinion on the elevation of some basalt slivers in Klondike Canyon in relation to the main mass of basalt, and on the existence of a scarp in older alluvium in Adobe Valley. Similarly, they note the presence of a "...conspicuous north-south valley running from just west of Antelope Mountain to the highway a mile southwest of Benton Hot Springs", stating that the fault may actually be more continuous than is shown on their map. They did not map any continuation of the Benton Valley fault into the Glass Mountain quadrangle, although they do show a normal fault having a similar trend but opposite sense of displacement about one mile northwest of the Benton Valley fault as mapped by Crowder and others (1972).

SUMMARY OF AVAILABLE GEOPHYSICAL DATA

Geophysical surveys of the region suggest that a major, relatively simple fault zone bounds the western border of the White Mountains (Pakiser and others, 1964; Oliver and Robbins, 1978). Oliver and Robbins show a narrow, north-trending gravity low along the White Mountains fault zone, wrapping northeastward toward Nevada in the area evaluated herein. Also, their map shows a gravity high located in the southern part of the Adobe Valley east of the Black Mountain fault. This fault locally may coincide with a gravity gradient.

Based on similar gravity data, Oliver and Robbins (p. 50) indicate that the White Mountains fault zone dips steeply and may be vertical. They also state that, to the south of the FER study area, the displacement across the White Mountains fault zone may be as great as 8000 feet (2400 m).

SEISMICITY

The faults evaluated in this FER lie in a region of scattered seismicity.

No alignment of epicenters is readily apparent along any of these faults in this area, however (Real and others, 1978).

INTERPRETATION OF AERIAL PHOTOGRAPHS

U.S. Bureau of Land Management (1977) aerial photographs were interpreted in order to detect features indicative of recent surface-fault rupture. The most prominent feature noted is the northwest-trending scarp in alluvium at Benton Valley Ranch (Bramlette Ranch on Figure 2A). The aligned springs noted by several workers (Anderson, 1933; Gilbert, 1938; Crowder and others, 1972; see above) as coinciding with the scarp are very apparent on the photographs interpreted. It appears from the photos that the scarp has not been significantly degraded. In general, the scarp appears to coincide with the fault scarp mapped by Crowder and others (1972), but locally is up to 400 feet away from the fault they depict. However, near and east of U.S. Highway 6, the fault seems to not be as well expressed. Discontinuous scarps and tonal lineaments exist locally near and east of the highway. These scarps and tonals appear to lie within older (late Pleistocene) alluvium, and the general trend of these features is nearly east-west, unlike the well-defined scarp near Benton Valley Ranch. Evidence of Holocene fault movement along this east-trending segment is lacking. If the Benton Valley fault continues to the southeast, it apparently is obscured by late Holocene fan deposits.

To the northwest of the ranch, the fault is difficult to follow in the rugged, basalt-capped terrain. Some scarps are visible on the photographs, and locally appear to comprise a wide zone of discontinuous faults. Individual scarps in the zone face either northeast or southwest. The features visible on the photographs suggest that the fault may consist of a somewhat broad zone of faults to the northwest, if an active fault in fact continues in that direction. Time did not permit a full evaluation of this complex of scarps, and they have normally not been ploted on the figures accompanying this report.

As earlier workers have indicated, the steep escarpment and somewhat dissected triangular facets present along the western flank of the White Mountains (Figures 2A and 2B) suggest that a major, recently active fault approximately coincides with the range front. It is clear from the photographs that a tremendous amount of debris has been discharged from the mountains, virtually covering any topographic feature, large or small, that lies west of the mountain front. However, along Marble Creek (SE 1/4 of Section 11, T. 2 S., R. 32 E.; Figure 2B) a well-defined scarp is visible across what appears to be alluvial deposits at the mouth of the canyon. Furthermore, it appears that this scarp displaces two terrace levels, although it does not appear to offset a third, more recent stream terrace. To the west, a small backfacing scarp is evident. Another scarp acroos a young fan is present at Rock Creek (SE corner of Figure 2B). Locally, broad scarps are visible in older fan deposits. From this evidence, it appears clear that a major, late Quaternary range-front fault bounds the western side of the White Mountains.

No other fault scarps were apparent in the fans flanking the White Mountains. Locally scarps which can be traced only a few hundred feet at the most are visble, but it appears that these probably mark the terminus of debris flows (most of these scarps are not depicted).

As noted above, Crowder and others (1972) depict some faults cutting older alluvium southwest of Benton. Several well-defined tonal lineaments are apparent on the photographs interpreted (Figure 2B). However, these tonals do not appear to be expressed in the topography. No scarps were evident in the fan deposits along the west flank of Blind Spring Hill.

A series of west-facing scarps in bedrock and older alluvium exists along the Black Mountain fault zone. The longest and most prominent of these scarps is a slightly sinuous feature which appears to offset an older alluvial fan near the mouth of Black Canyon (Figure 3,sheets B and C). Some escarpments were evident to the south, but these features may be the result of stream erosion, fault movement, or both. Similar scarps in older fan deposits also exist a short distance to the southeast (Figure 3, sheet D). Since the regional dip of these older fan deposits is to the east and the faults scarps all exhibit evidence of down-to-the-west movement, one would expect that drainages crossing the fault traces prior to uplift of the downstream portions would be dammed as a result of fault displacement. No evidence of closed depressions or ponded alluvium was evident on the photographs interpreted, suggesting that sufficient time has passed for the streams to breach the scarps and any ponded alluvium to be completely eroded away subsequent to the latest fault movement.

Time did not permit plotting of all of the fault-related features in the upland areas of Black Mountain. However, a brief analysis did not disclose any features which were incompatible with those already described.

RESULTS OF FIELD RECONNAISSANCE

Approximately 3 days were spent in the field in an attempt to obtain definitive data about the fault locations and recent history. No soil scientist was available at the time this investigation was conducted; thus, the observations and conclusions concerning the relative dating of the soils should be considered tentative.

The scarp across stream terraces apparent along Marble Creek (see above) was not detected until after the field reconnaissance was completed. Due to the apparent lack of any other, obviously recent, scarps in any of the fan deposits in California along the western margin of the White Mountains, no field observations were made in that area. However, the scarps reported by Anderson (1933) and Crowder and others (1972) as being in older fan deposits in Nevada were briefly checked. The presence of scarps across the Queen fan was confirmed. Exposures of soils in borrow pits on the fan revealed a reasonably well-developed B-horizon and pedogenic calcite zones about 0.5 m thick. Thus, it appears that the bulk of the fan is probably pre-Holocene in age. In addition, the fact that the scarps observed had several small drainages incised in them suggests that scarps should not be considered to be late Holocene features. The height of the scarps (5 m or more) is impressive, and suggests that movements along the faults in this zone have repeatedly occurred.

The Benton Valley fault is marked by a scarp about 7 m high and ranging up to 30 m wide. Test pits were excavated on both sides of the scarp to depths of up to 32 inches. Except for test pit 1 (Figure 2B), the units exposed did not appear to have developed any B-horizons and the pebbles recovered lacked coatings of caliche. Thus, it appears that these deposits are quite young. If we assume that the deposits displaced by the Benton Valley fault are less than 10,000 years old, then the eastern block has been rising at a rate of 0.7 mm/year or more.

Test pit 1 was excavated in older alluvial deposits, and had a well-developed B-horizon about 2 inches thick located about 14 inches beneath the surface. Test pit 2, located in an area mapped by Crowder and others (1972) as older alluvium, appeared to be slopewash and aeolian sands to a depth of 30 inches. Thus, the fault may cut the older fan deposits but any scarp which might have once existed could have been covered by these younger deposits. Most of the springs located along the fault have been modified to permit their use by men and/or cattle. No actual fault exposures were observed along this zone.

An attempt was made to determine the origin of the tonal lineaments east of "Pedro Ranch" (Figure 2B). The deposits here appeared to be quite old (based on the somewhat weathered appearance of the many large boulders exposed at the surface), but the cause of the tonals was not apparent on the ground. They do not appear to be expressed in the topography. A brief examination of the south-facing escarpments in this same general area did not disclose whether these escarpments were produced by erosion, faulting, or both.

The faults mapped by Crowder and others (1972) in the area southwest of Benton and identified as tonal lineaments during the interpretation of aerial photographs (see above and Figure 2B) were checked. No scarps or similar features were observed in the field. The tonal lineations were not apparent on the ground.

In the central part of the Glass Mountain quadrangle (Figure 3), Krauskopf and Bateman show several west-facing faults. As noted, several scarps are apparent on the aerial photographs interpreted. In the field, the scarps do not appear as impressive as on the photographs. In general, they are somewhat sinuous, locally broad, and locally discontinuous features. A test pit (TP 5 on Sheet C) excavated in the older fan deposits suggests that these deposits are quite old (a well-developed B-horizon 3 to 4 inches thick,located about 7 inches below the surface; cobbles in the soil have been almost completely coated with caliche). No faults were observed in streambank exposures at the mouth of Black Canyon, and no scarps were evident in the young alluvial deposits along any of the faults mapped. No ponded alluvium was evident along any of the scarps mapped.

CONCLUSIONS

The Benton Valley fault is a locally well-defined, normal fault which apparently displaces Holocene alluvial deposits. The height of the scarp near Benton Valley Ranch (Bramlette Ranch on Figure 2A) suggests that the area northeast may have risen at a rate of 0.7 mm per year or more. Time did not permit any definitive conclusions to be reached concerning the distal ends of this fault. However, the Benton Valley fault may be part of the White Mountains fault zone.

The White Mountains fault zone appears to be sufficiently active and well defined through most of the study area. In the vicinity of Marble Creek, a well-defined scarp crosses what appear to be two alluvial terraces, probably latest Pleistocene or earliest Holocene in age. The steep escarpment and numerous triangular facets locally serve to identify the approximate trace of the active fault. Elsewhere, the alluvial fans fronting the west side of the White Mountains locally have concealed any recently active traces that exist.

The scarps across the Queen fan in Nevada and at Marble Creek in California demonstrate that some faults in this zone have been active during latest Quaternary time. Also, the steep western face of the range suggests that fault movements have occurred in fairly recent (late Quaternary) time. As noted above, the Benton Valley fault may be a branch of the White Mountain fault zone. Taken in combination, these facts strongly suggest that a major Holocene fault exists along the mountain front. Although the fault zone is also sufficiently active and well defined to warrant zoning several miles to the south (Bryant, 1984), a brief examination suggests that most of the the fault is concealed by alluvium in the intervening area (the southernmost part of the area studied herein and the 7.5-minute quadrangle to the south). [**EWH** (reviewer's) **NOTE**: A scarp across a young fan at Falls Canyon in the White Mountains NW quadrangle indicates the active fault extends to the south].

The faults southwest of Benton, mapped by Crowder and others (1972) and identified as tonal lineaments during this study (Figure 2B), do not appear to be major faults since no scarps or other evidence of fault movement was observed in the field. The tonal lineaments may result from infilling of fissured ground or other causes; however, the features do not appear to represent a significant hazard based on this analysis.

A preliminary evaluation of the Black Mountain fault zone failed to uncover any definitive evidence of Holocene fault movement. Geomorphic features observed on the photographs and in the field, coupled with the data gathered from a small soil pit, suggests that the faults evaluated cut Pleistocene alluvial fans and but probably have not been active during the latest Holocene.

A brief scan of the aerial photographs suggests that the study area has been subjected to extension in the recent geologic past and that the pattern of faulting is very complex. Also, in addition to the Benton Valley fault, it appears likely that other, active (Holocene) faults exist in remote parts of the Glass Mountain quadrangle and may exist in the Benton quadrangle. Some of these probable faults do not appear on existing geologic maps of the area. Other faults are depicted in a somewhat generalized fasion on maps by Crowder and others (1972) and Krauskopf and Bateman (1977). However, these two data sources do not appear sufficient to enable a quick determination of just which faults are recently active and are sufficiently generalized that they may not be appropriate to use in plotting any faults which should be zoned.

RECOMMENDATIONS

Based on the information presented herein, zoning of the Benton Valley fault and most of the White Mountains fault is recommended (Figures 4A and 4B). Information from this FER and Crowder and others (1972) should form the principal sources used.

No other faults or segments of faults should be zoned at this time. Although other active faults undoubtedly exist in the study area -- particularly in the Glass Mountain quadrangle -- the time available did not permit a thorough analysis of the numerous Quaternary faults to be made. A substantial amount of time is needed to complete such an analysis.

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Reviewed; recommendations approved.

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April 6, 1984

REFERENCES

Anderson, G.H., 1933, Geology of the north half of the White Mountain quadrangle, California-Nevada: Ph.D. thesis, California Institute of Technology, 250 p., figures, 2 plates. [A decent copy of this map is in Jenning's files].

Bryant, W.A., 1984, Northern Owens Valley, Fish Slough, and White Mountains frontal faults, Inyo and Mono Counties: California Division of Mines and Geology Fault Evaluation Report FER-153.

Christensen, M.N., Gilbert, C.M., Lajoie, K.R., and Al-Rawi, Yehya, 1969, Geological-geophysical interpretation of the Mono Basin, California-Nevada: Journal of Geophysical Research, v. 74, no. 22, p. 5221-5239.

Crowder, D.F., and Sheridan, M.F., 1972, Geologic map of the White Mountain quadrangle, Mono County, California: U.S. Geological Survey Geologic Quadrangle Map GQ-1012, scale 1:62,500, 1 sheet.

Crowder, D.F., Robinson, P.T., and Harris, D.L., 1972, Geologic map of the Benton quadrangle, Mono County, California, and Esmerelda and Mineral Counties, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ-1013, scale 1:62,500, 1 sheet.

Gilbert, C.M., 1938, The Cenozoic geology of the region southeast of Mono Lake, California: Ph.D. dissertation, University of California, v. 181 p., 2 plates, scale 1:125,000.

Gilbert, Charles M., 1941, Late Tertiary geology southeast of Mono Lake, California: Bulletin of the Geological Society of America, v. 52, p. 781-816.

Hart, E.W., 1980, Fault rupture hazard zones in California: California Division of Mines and Geology Special Publication 42, 25 p., 2 supplements.

Jennings, C.W., 1975, Fault map of California with locations of volcanoes, thermal springs and thermal wells: California Division of Mines and Geology Geologic Data Map No. 1, scale 1:750,000, 1 sheet.

Krauskopf, K.B., and Bateman, P.C., 1977, Geologic map of the Glass Mountain quadrangle, Mono County, California, and Mineral County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ-1099, scale 1:62,500, 1 sheet.

Nevin, A.E., 1963, Late Cenozoic stratigraphy and structure of the Benton area, Mono County, California: M.A. thesis, University of California, Berkeley. [Not available for review in CDMG library].

Oliver, H.W., and Robbins, S.L., 1978, Mariposa sheet: California Division of Mines and Geology Bouguer Gravity Map of California, scale 1:250,000.

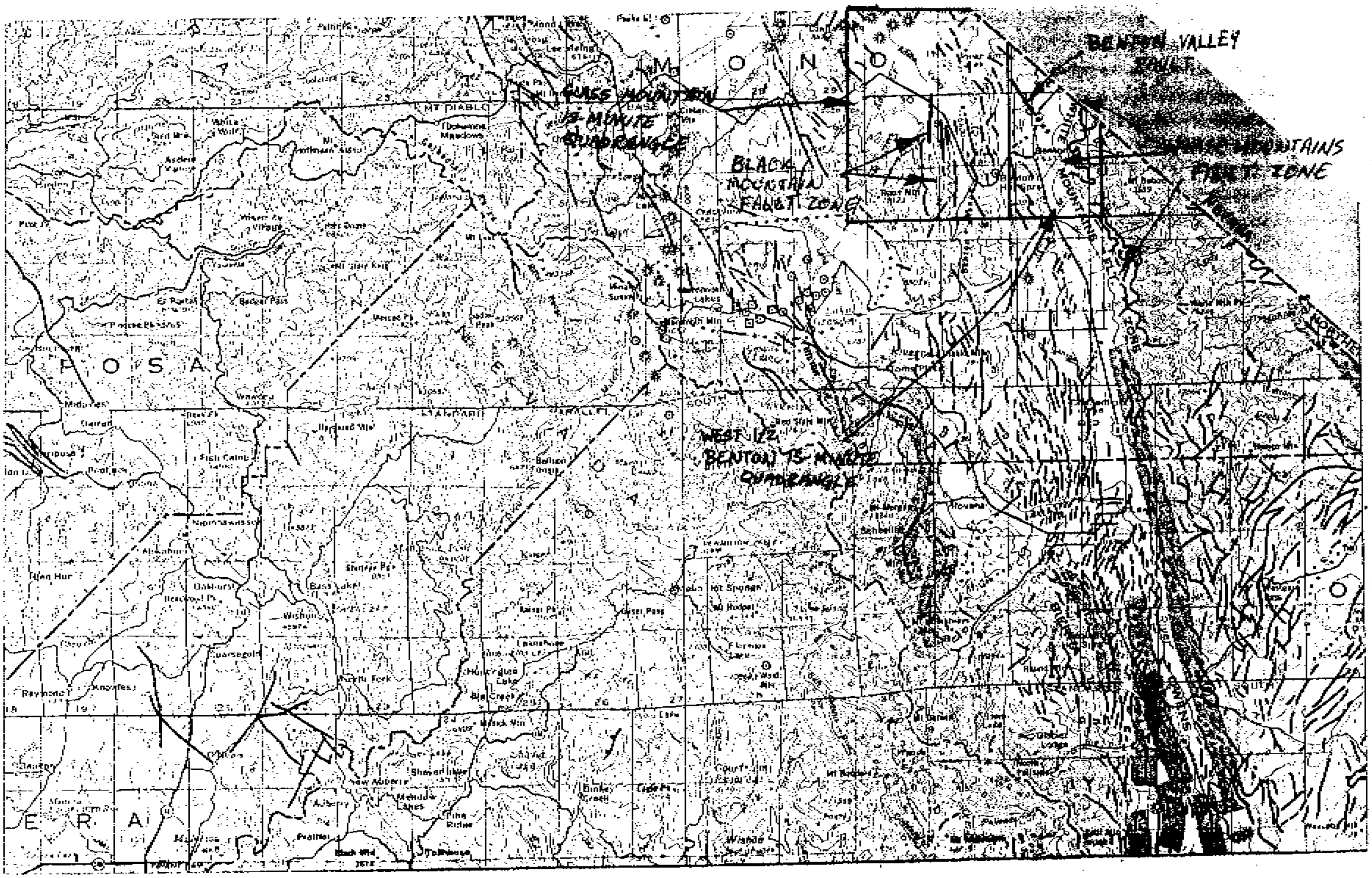
Pakiser, L.C., Kane, M.F., and Jackson, W.H., 1964, Structural geology and volcanism of Owens Valley region, California — a geophysical study: U.S. Geological Survey Professional Paper 438, 68 p., 3 plates.

Real, C.R., Toppozada, T.R., and Parke, D.L., 1978, Earthquake epicenter map of California showing events from 1900 to 1974 equal to or greater than magnitude 4.0 or intensity V: California Division of Mines and Geology Map Sheet 39, scale 1:1,000,000.

Rinehart, C.D., and Ross, D.C., 1957, Geologic map of the Casa Diablo Mountain quadrangle, California, : U.S. Geological Survey Geologic Quadrangle Map GQ-99, scale 1:62,500, 1 sheet.

Taylor, R.L., 1965, Cenozoic volcanism, block faulting, and erosion in the northern White Mountains, Nevada: M.S. thesis, University of California, Berkeley. [Not available for review in CDMG library].

U.S. Bureau of Land Management, 1977, Color aerial photographs, series CA01-77, numbers 1-31-28 to 1-31-35, 4-23-1 to 4-23-11, 4-25-16 to 4-25-31, 4-28-25 to 4-28-37, 4-29-25 to 4-29-37, 6-26-16 to 6-26-27, 6-30-26 to 6-30-35, scale 1:24,000.



FER-161. Figure 1. Location of the faults evaluated in this FER (after Jennings, 1975), showing quadrangles.

FER-161. Figure 3, sheet A (legend for sheets B, C, and D). Information on faults in the central part of the Glass Mountain 15-minute quadrangle. Base map is a 1:24,000 manuscript map [originally tentatively named "Benton", subsequently changed to Glass Mountain]. Information in black is from Krauskopf and Bateman (1977). Information in red was developed for this FER. The latter data are from aerial photo interpretation except where noted [e.g., "field:..."].

Krauskopf and Bateman (1972) symbols:

Fault, dashed where approximately located, dotted where concealed or inferred. Bar and ball on downthrown side. Faults along margins of alluvium-filled basins shown as solid lines, although actual fault is concealed.

Qa = Youngest alluvium and talus (Holocene and Pleistocene).

Qof = Older alluvial fan deposits (Pleistocene).

Qte = Terrace deposits (Pleistocene).

Air photo and field data symbols:

Scarp, hachures indicate direction it faces.

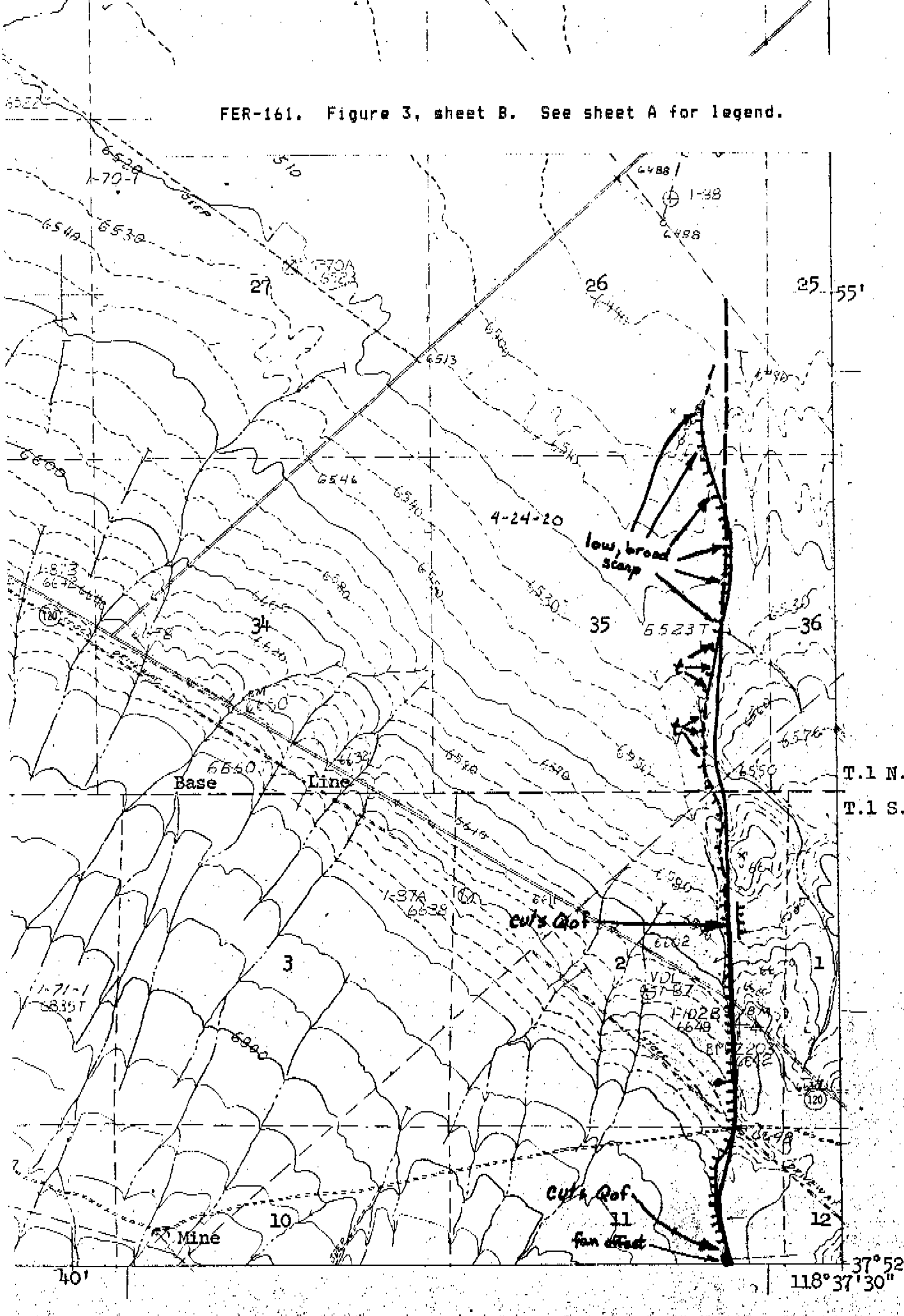
Scarp that clearly offsets older fan deposits.

Location of lineation or scarp, dashed where approximately located.

t = Tonal lineament

TP3 = Location of soil test pit

FER-161. Figure 3, sheet B. See sheet A for legend.



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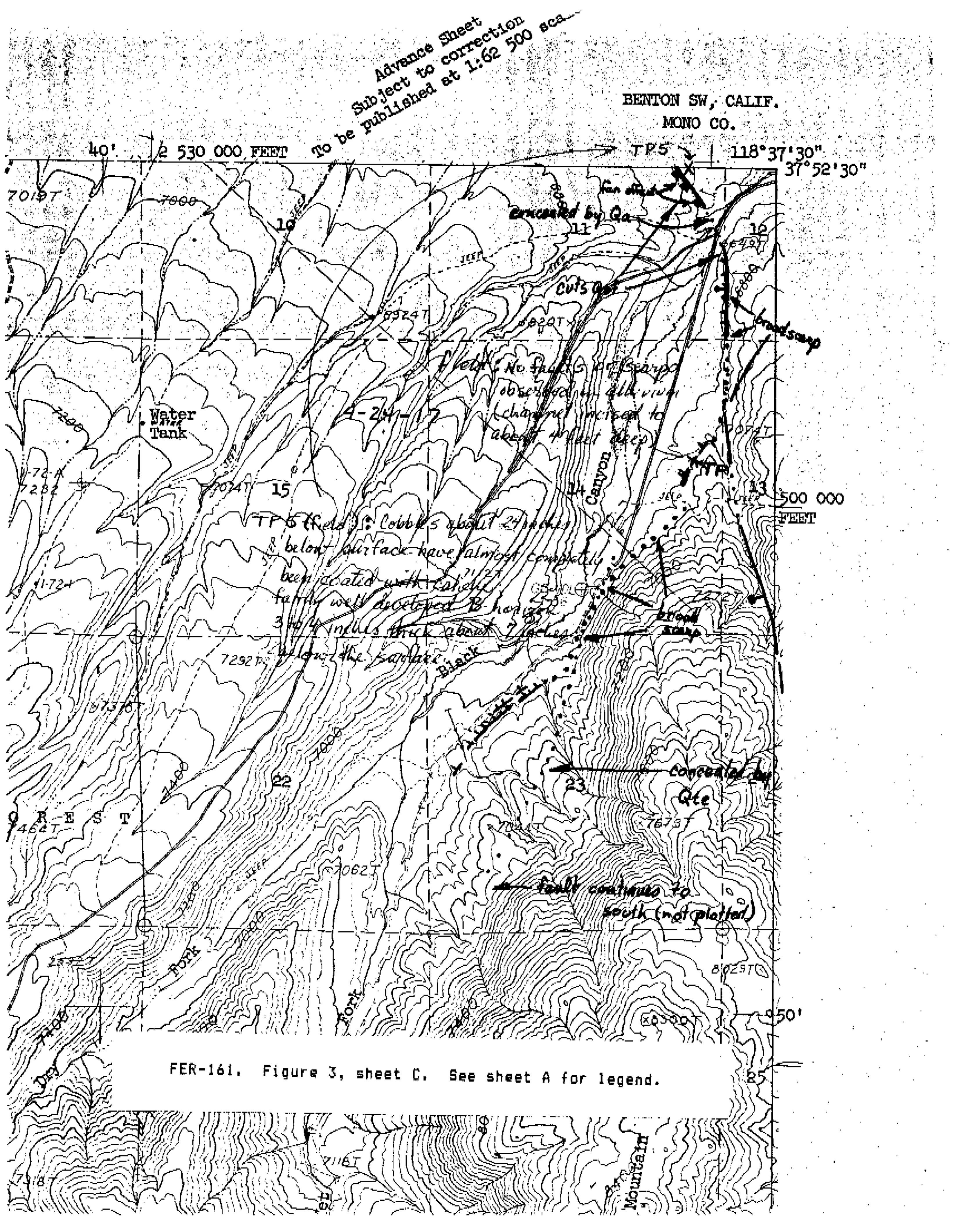

FER-161. Figure 3, sheet C. See sheet A for legend.

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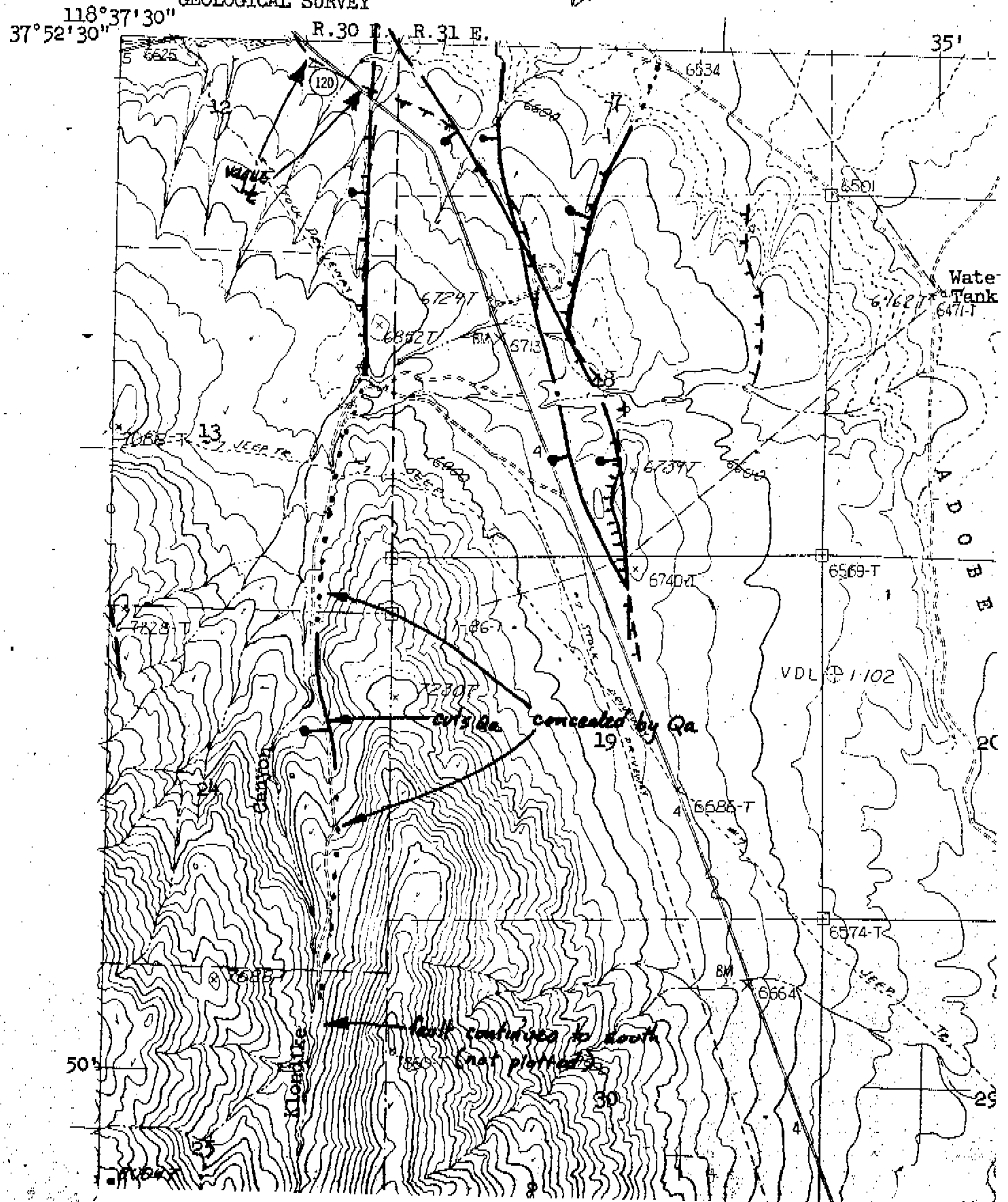

FER-161. Figure 3, sheet D. See sheet A for legend.